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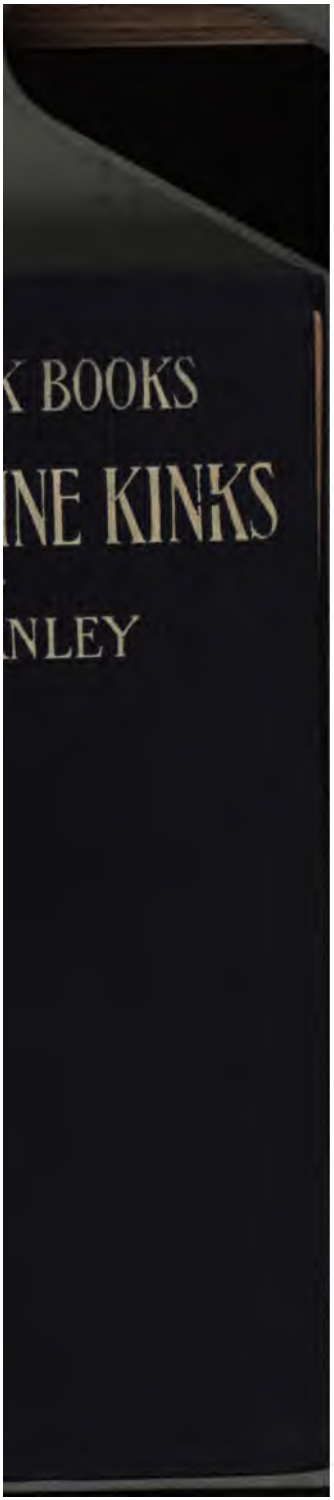
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THE HILL KINK BOOKS

Milling Machine K

COMPILED BY

F. H. COLVIN AND F. A. STANI

Associate Editors of American Machinist

1908

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6 BOUVERIE STREET, LONDON, E.C.

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INTRODUCTORY WORD

THE kinks and other information given in this book have been selected from the experience of thoroughly practical men, as originally published in the *American Machinist*. This volume forms one of a series of this nature, aiming always to make available out-of-the-way information when most wanted. In this form the Kink Books, which can be kept in the tool-chest or the pocket, and always referred to, will, we feel, meet a demand and serve a good purpose.

F. H. COLVIN.
F. A. STANLEY.

NEW YORK, November, 1907.

MILLING MACHINE KINKS

MILLING MACHINE FEEDS AND SPEEDS

THE determining of the proper feeds of milling cutters in the past was usually a matter of guesswork, or experience, as a good many would term it, no absolute rule of any kind having ever been established.

On the other hand, the speeds of milling cutters have been fairly well established. A good average for the surface speed of an ordinary tool-steel cutter, when used in a milling machine, is 20, 40, 60 feet respectively for steel, cast iron and brass. For the air-hardening tool-steel cutter, the surface speed may be increased from 50 to 75 per cent. The surface speed of an ordinary tool-steel cutter, when used in a standard gear cutting machine, is generally 40, 60 and 80 feet respectively for steel, cast iron and brass. This increase in surface speed over the regular tool-steel milling

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cutter is due to the fact that the conditions of the standard gear cutting machine have been so provided to adapt it for just one kind of work where the overhang of parts is reduced to a minimum. The object of this article is to demonstrate that a guide for determining the proper feed of milling cutters is found in ascertaining the thickness of the chip per tooth of the cutter.

Let us take, for example, an average size milling cutter working in cast iron, say 2½ inches diameter, 3 inches long, with eighteen teeth, which is quite commonly used, and we will find that the thickness of the chip per tooth is quite small, resulting in .0018 inch, with a table feed of 2 inches per minute. This is entirely too slow. Now, comparing this cut of .0018 inch with a lathe tool cut, with which all of us are familiar, we readily see that such a chip in a milling cutter is much smaller and is far more injurious to the cutter than a heavier feed, since the cutting edge of a tool will hold up longer in cutting into the metal instead of scraping it. A standard 6-pitch gear cutter cutting cast iron at the rate of 5½ inches per minute, averages a chip per

tooth of only .0067 inch. The gear cutter is here mentioned only to demonstrate the possibilities of other classes of milling cutters.

A cutter is very seldom ruined by the feed, but is generally ruined by overspeeding it. If we take for instance a cutter of thirty teeth with a table feed of .300 inch per revolution, the chip per tooth will then only be $\frac{.300}{30T} = .010$ inch thick — still quite a light cut when comparing it with a lathe tool chip. Hence in many cases of milling, if we guide our feeds by the thickness of chip per tooth, a much faster feed would be used more generally, since it is evident that the heaviest feeds, comparatively, give only a thin chip per tooth.

The question of power in milling is to-day quite an important subject, and a great deal depends on the form and shape of cutter used. Roughing cutters should invariably be coarse-toothed, and, if possible, never have more than two or three teeth in contact with the metal.

Below are tabulated the results of a test of power consumed by two identical roughing cut-

ters, Figs. 1 and 2, with the exception that one contained thirty teeth and the other fifteen teeth:

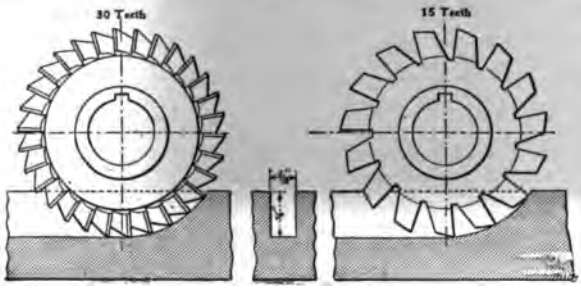

FIG. 1. — 5 Teeth in Contact.

FIG. 2. — 3 Teeth in Contact.

Comparison of Fine and Coarse Pitch Cutters.

TEST IN CAST IRON

	Fig. 1. Cutter	Fig. 2. Cutter
Diameter of cutter	4″	4″
No. of teeth in cutter	30	15
Width of cutter	$\frac{9}{16}$″	$\frac{9}{16}$″
Depth of cut	$\frac{7}{8}$″	$\frac{7}{8}$″
No. of teeth in contact with metal	5	3
Volts	110	110
Amperes	13.5	10.5
Feed of table	.134″	.134″
Rev. of cutter p. m.	40	40
Thickness of chip per tooth	.0044	.0088

The machine on which this test was made was No. 3 Cincinnati motor-driven, positive-feed iller connected with a Weston volt ammeter, so at very accurate readings of the power required r the two cutters could be taken. Observe that e 30-tooth cutter required 13.5 amperes, while e 15-tooth cutter required only 10.5 amperes ı the same cut, a saving of about 22 per cent. ıis is plainly obvious, since the 30-tooth cutter ıd constantly 5 teeth in contact with the iron, hile the 15-tooth cutter had only 3 teeth in ntact, proving that the more bites a cutter ust take, the more power is required, irrespec-ve of the fact that the 15-tooth cutter took a rger chip per tooth than did the 30-tooth cutter. This clearly demonstrates the advantage of a ıarse tooth cutter for heavy milling, not only ırough its economic use of power, but also ɔcause of its greater durability. A cutter of ıis kind will also permit of a heavier feed, pecially on deep cuts, since ample space exists ɔtween the teeth for the escape of the chips, hich would be impossible with a fine tooth ıtter.

For finishing cuts a finer tooth cutter should be used, which will greatly lessen the feed marks for a smooth milled surface. This is quite readily permissible, since these cutters have no great amount of metal to remove, and the space between the teeth is ample for the escape of the chips.

The points enumerated above need not be absolutely adhered to for ordinary milling, but if the very best results are aimed at with a view of increased production, it would be well to bear them in mind, especially when constructing roughing and finishing gangs.

Great care should be exercised when sharpening cutters to give them the proper angle for clearances, the life of the cutter being thereby materially lengthened. A 5-degree clearance for finishing and 7-degree clearance for roughing produces very good results.

Whenever feasible, as small a cutter as possible should be used. They are not only less costly, but require less power for driving when milling.

When milling steel, a heavy flow of oil on a milling cutter, forced by means of an oil pump,

is just as essential as the great volume of oil which is used on automatic screw machine tools, which would not hold up one-half hour if not so flushed. The life of a milling cutter amply lubricated will be materially prolonged and it will be capable of standing a much heavier feed.

The foregoing remarks apply to practice in general, but on jobs where conditions are favorable still better results can be obtained. For example, we have milled with an end mill 3 inches diameter, 20 teeth, 2½-inch face, at a table feed of 15 inches per minute. This mill was mounted on the nose of a horizontal spindle miller where there is no overhang, and ran at a surface speed of 40 feet per minute. The milling machine table in this case advanced .300 inch per turn of the cutter, which gave a chip per tooth of .015 inch. This same piece was then finished with a table feed of 25 inches per minute with the cutter rotating at a surface speed of 65 feet per minute, producing a surface so smooth that the cutter marks could be easily polished off by means of emery cloth. After milling thirty

WHEN the assembling departmen
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we suspected that the trouble was
ıethod of "hand rolling," or the
olding a gear in each hand and rolli
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For demonstration we provided a
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For instance, the curve of one side of one cutter was of a greater radius or length than that of opposite side; in another, one curve was not in a position directly opposite its mate, as shown, exaggerated, in Figs. 3 and 4.

Fig. 5 shows the end of a gear blank having one space cut and a line drawn vertically through center of space. If each half of space cannot be made an exact counterpart, either by reason of defective setting (and we are not trying to place all the blame on the cutters), or imperfections of cutters, a compromise must be effected. The compromise should affect least those portions of the curves adjacent to the pitch line. The method here described will produce the compromise:

The cutter is first set approximately central and the blanks are mounted in the usual manner and the table raised as in Fig. 6. The cross-slide is moved back and forth while the cutter is running, and the table gradually raised until the cutter touches the blank in passing, as in Fig. 7, and produces a spot somewhat like *a* or *a*,′ Fig. 8. Then the table is raised higher, still

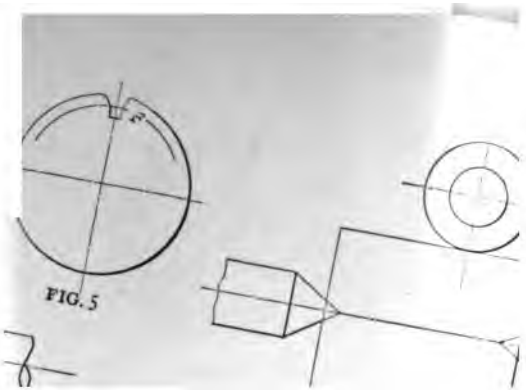

FIG. 5

gradually, while the cross-slide is being adjusted so that the edges of grooves *b* or *d*, being cut, coincide laterally with *a* or *a'*. If the table is raised high enough to make *c* equal to the width of space at the pitch line while the cross-slide is being adjusted, the points of curve adjacent to the pitch line, Fig. 5, will be exactly central. The shapes of *a a'* will of course vary as the relative relations of diameters of cutters and blanks and the depth of spots, but the spots are always central on either straight or taper work.

Another advantage of this method is that all setting marks are in one line and in a position that insures their removal when a space is being cut. This method was found to be much quicker and safer than the old way and could be taught to anyone, as correct eyesight was not especially necessary. Afterwards we found it useful when setting for other operations, as milling keyways, slots, and in fact for practically all operations where a space to be cut was to bear some fixed relation to the center of the work.

a heart cam as a feed for a
in which the coils were r
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part broken off, and it was t
When this cam was tested th
numerous small errors which
overlap and wind unevenly.

It was then proposed to m
following manner: Lay out the
roughly, as in Fig. 9. Drill an
side stock, being sure to leave
overcome errors in laying out.
the nut arbor and tighten secur
of the cam is $\frac{1}{8}$ radius, select
having

also make a difference to the other points on the curve of the cam, which is not quite so apparent at first glance.

The next operation is to place the cam between centers on the milling machine, having the cutter in line with the vertical radius of the cam, at its lowest point. Next choose an index circle which will give a division of the cam, such, that the rise of each division will be in thousandths of an inch, if possible. For this cam we take a circle which will give 200 divisions. As this will make 100 divisions on a side, the rise of each division will be 0.011 of an inch. Now raise the table to the required hight, starting at the lowest point of the cam, and mill across, as in Fig. 10.

For the other cuts lower the table 0.011 each time, and revolve the cam one division until the highest point of the cam is reached, then raise the table 0.011 for each division of the cam.

When the cam comes from the milling machine there will be found to be small grooves left between the cuts. These may be easily removed by smoothing off with a file without impairing the accuracy of the cam.

become accustomed to the n

FIG. 9. — Method of Laying Out Cam.

FIG. 1(
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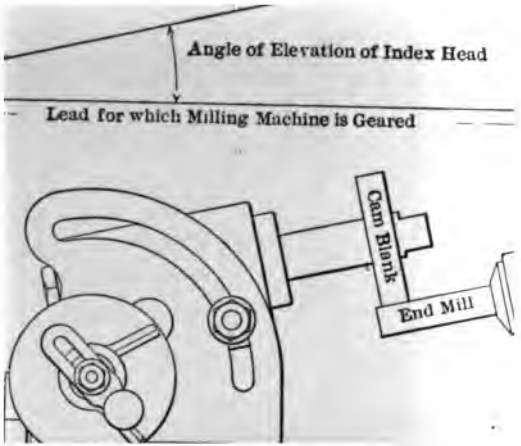
A NEW WAY

proper gears on hand. But, by the method here shown, we may mill cams of any rise with the gears regularly furnished with the milling machine.

With the head set vertically the lead of the cam would be the same as the lead for which the machine is geared, while with the head horizontal and the milling spindle also, a concentric arc, or rest, would be milled on the cam, regardless of how the machine was geared. By inclining the head and milling spindle, we can produce any lead on the cam less than that for which the machine is geared. The head being inclined brings the cam farther from the end of the table, and so does away with the extension shaft which sometimes is a necessary feature when milling a plate cam.

The method of finding the inclination at which to set the index head is shown in Fig. 11, and is simply the solution of a plain right-angled triangle, in which the hypotenuse represents the lead of the machine, and one of the other sides represents the lead we wish to produce on the cam. By dividing the latter by the former we get the sine of the angle of inclination.


Angle of Elevation of Index Head
Lead for which Milling Machine is Geared
Cam Blank
End Mill

Take for illustration a plate cam having $\frac{1}{8}$-inch rise in 300 degrees.

$$\frac{360}{300} \times \tfrac{1}{8} = 0.15,$$

which is the lead we want on the cam, while the slowest lead for which the B. & S. machine can be geared is 0.67.

$$\frac{0.15}{0.67} = 0.224.$$

Consulting a table of sines, we find 0.224 comes pretty close to being the sine of 13 degrees, which is the angle at which to set the head; and if the milling spindle is also set at the same angle, the edge of the cam will be parallel with the shaft on which it is to run. Fig. 11 shows a milling machine set for this job.

When a cam has several lobes of different leads, we gear the machine up for a lead somewhat longer than the longest one called for in that cam, and then all the different lobes can be milled with the one setting of gears, by simply altering the inclination of head and milling spindle for each different lead on the cam.

If the diameter of the cam and the inclination

of the head will admit, it is better to mill on the under side of the cam, as that brings the mill and table nearer together and thus increases rigidity, besides enabling us to easily see any lines that may be laid out on the flat face of the cam. Also the chips do not accumulate on the work.

The work is fed against the cutter by turning the index crank, and on coming back for another cut we turn the handle of milling-machine table. As a result the work will recede from the cutter before the cam blank commences to turn, owing to back lash in the gears, thus preventing the cutter from dragging over the work while running back.

In this way we use to advantage what is ordinarily considered a defect in machine construction.

The milling machine, when used as shown in Fig. 11, will be found to be more rigid than when the head is set in the vertical position, and the cams will work more smoothly on account of the shearing action of the cutter.

One possible objection to the method here

advocated is the necessity of using, in some cases, an end mill of extra length of tooth. In practice, an end mill $\frac{1}{8}$ inch diameter and $3\frac{1}{2}$ inches length of tooth is not unusual; but the results in both speed and quality will be found entirely satisfactory.

CUTTING RACKS ON THE MILLING MACHINE

A JOB came in one day that called for the cutting of a rack ratchet a little over 6 inches long, and with 32 teeth per inch. The most natural way to do this job was to hold the blank in the milling machine vise and space the teeth by means of the dial on the cross-feed screw, moving 0.03125-inch each time. But this is an awkward move to handle, and as it would have to be repeated about 200 times in the length of rack to be cut, and that quarter-thousandth might mix us up, we thought of making a special dial for this particular job, and thus lessen the liability of making mistakes. As the cross-feed screw had 5 threads per inch, we might have made a dial

with 32 divisions and moved 5 of these each time, but instead of this we graduated a dial in 64 equal parts and then moved 10 divisions each time, to get a movement of the race blank of $\frac{1}{32}$ inch. As 10 exact divisions were moved each time, it was a comparatively easy job to keep

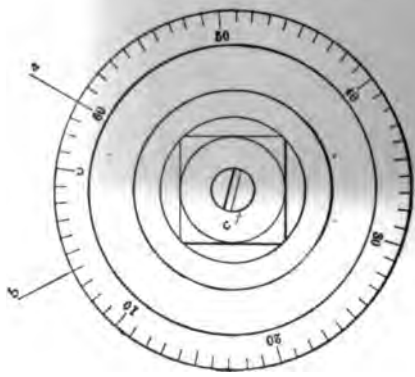


FIG. 12. — Special Dial for Milling Machine.

track of them, and not "lose the place." The dial was set to read 0 for the first cut, and subsequent readings were 10, 20, 30, 40, 50, 60; 6, 16, 26, 36, 46, 56; 2, 12, 22, 32, etc. In the sketch, Fig. 12, *a* is the regular line scratched on the knee to read against, and *b* is a pencil or

chalk mark put on for the job in hand, 10 divisions away from *a*, and serving to indicate the division on the dial that is next to be brought to

TABLE I. — For Use in Cutting Racks on the Miller

Pitch of rack	Movement of cross-feed dial	Error on circular pitch
8	$1\frac{18}{55}$	.00003 c
9	$1\frac{11}{55}$	.00002 c
10	$1\frac{12}{56}$	.00012 c
11	$1\frac{24}{55}$	.00011 c
12	$1\frac{17}{55}$	.00002 c
14	$1\frac{5}{11}$	.00001 f
16	$\frac{24}{55}$	.00001 c
18	$\frac{18}{55}$	.00002 c
20	$\frac{14}{56}$	.00006 c
22	$\frac{12}{56}$	.00006 c
24	$\frac{6}{55}$	.00001 c
26	$\frac{4}{13}$	.00023 c
28	$\frac{28}{11}$	.00000
30	$\frac{22}{11}$	.00004 c
32	$\frac{27}{55}$	.00001 c
36	$\frac{24}{55}$	.00001 c
40	$\frac{22}{56}$	.00003 c
48	$\frac{18}{55}$	.00000

tally with *a*. The chalk mark *b* is not a necessary feature to be used with the special dial shown, but it serves as a check on the counting, and can

often be used to advantage with the dial regularly furnished by the makers.

The milling machine on which this job was done had the dial held in place by a small pin forced out radially by the taper-pointed screw *c*, so as to engage in a recess turned in the bore of the dial, but this pin was so gummed up with oil that it failed to drop when screw *c* was removed. By applying the mouth to the squared end of the screw and producing a partial vacuum with the lungs, the little pin was quickly pulled into its hole and the dial then taken off. When the new dial was put in place, a slight amount of wind pressure forced the little pin out again.

Having found how useful a special dial was when applied to the job mentioned, it seemed as if it might be advantageous to employ something of the sort when cutting diametrical pitch racks, and with this object in view Table 1 herewith was computed, which shows that a dial with 55 divisions is an extremely useful one to have on hand in a small job shop, as it enables us to cut racks of 8, 9, 12, 16, 18, 24, 32, 36 and 48 pitch

with a degree of accuracy well within practical limits.

Another useful dial is one with 56 spaces, as that will enable us to cut racks of 10, 11, 20, 22 and 40 pitch with very small errors of spacing. With a dial with 41 equal parts we can cut racks of 14 and 28 pitch practically accurate, and with a dial of 42 parts we can cut 30 pitch racks. Also a 76 dial will cut 26 pitch racks accurate enough for nearly every purpose.

All these special dials have coarser or more open divisions than the regular dial furnished with the machine, and are, in that respect, much easier to read. The letters *c* and *f* after the tabulated errors indicate whether the pitch produced by that particular move is coarser or finer than it should be.

SPACING DEVICE USED IN GRADUATING SCALES ON THE MILLER

Some time ago we had to graduate about a dozen scales; the distance between two lines was 0.05225 inch, or — as some mechanics read it —

fifty-two and one-quarter thousandths. It did not pay to make a special dividing machine, and on the milling machine, where the job had to be done, it was a rather tedious thing to read 0.05225

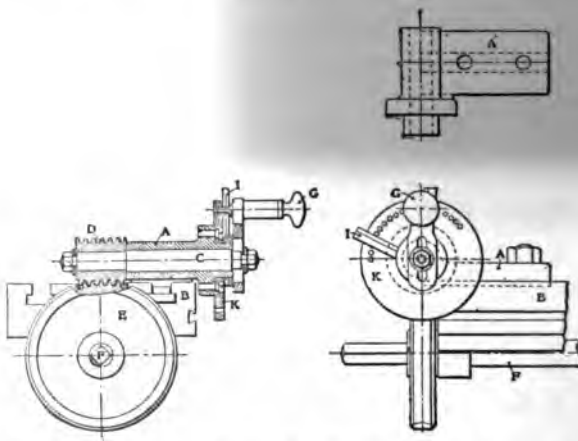


FIG. 13. — Spacing Device for Graduating Scales on the Miller.

on the dial; so we made the device shown in the drawing, Fig. 13, to do the spacing.

A bracket *A* was bolted to the table *B* of the machine, this bracket forming a bearing for shaft *C*. On one end of this shaft we fastened a worm

D, which meshed with worm wheel *E* on feed screw *F;* on the other end of shaft *C* we fastened the spring plunger arm *G*, which we took off from the regular index head. We also borrowed the sector *I* and plate *K*, which belong to the same head, and fastened the plate to bracket *A*. The plate had fifty holes (it had been made for some special job), the ratio between worm and worm wheel was 20 to 1, and the feed screw was ¼ inch pitch. By shifting the plunger *G* from one hole to the next one, the table was moved 1-4000, or 0.00025 inch. To feed 0.05225 inch, which is equal to 209-4000, we had to pass 209 holes on the index plate, which equal 4 turns and 9 holes. With the sector set for 9 holes between the two arms the spacing became a very simple operation.

ACCURACY IN JIG AND FIXTURE WORK ON THE MILLER

THE method of using buttons in locating holes in jigs and fixtures is one of the most accurate, as it has come to be one of the most universal

methods in use. This has been used successfully on available work, not only such as can be swung in the lathe, but also on work that is too large for the lathe, and which must be done in the milling machine. For this class of work a special indicator for setting the buttons in perfect alinement with the milling machine spindle has been designed. An example of the usefulness of this method may be found in a large leaf drill jig for the side frame plates of a cash register, with numerous bushing holes in the leaf, which is too large to be swung in the lathe. The location of the holes could, no doubt, be accomplished in several ways, in which the block method is one. By this method a square block with a hole accurately through its center is located on the leaf by its outer sides, clamped in position and used as a jig bush for the drill. This method, however, invites an error to be made too easily.

Another method would consist of placing the leaf on the milling machine and using the graduated dials of the machine, but this method seldom gives accurate results, especially after the screws have become worn by use. There are

many more methods that could be mentioned, but there is no method more accurate than the use of the buttons and the indicator shown in Fig. 14.

The leaf of the jig is first "buttoned up," this being a familiar shop term used when applying the buttons to a piece of work. It is needless to go into details here about buttoning up work. After this is accomplished the leaf is placed on the milling machine against an angle plate, to which it is held by clamps, as shown in Fig. 15. The indicator is then placed in the spindle of the machine and applied to a button, thus truing it perfectly with the center of spindle, after which the hole is made with drill and boring tool.

The buttons most generally used are made as shown in Fig. 15 at *c*. They are hardened, ground and lapped to fit a ring gage, ½ inch in diameter being a very convenient size. As will be seen from Fig. 15, the angle plate rests on two special parallels, which in turn are bolted to the milling machine table. The object of letting the angle plate project over the side of the table on the parallels is to permit the insertion of the

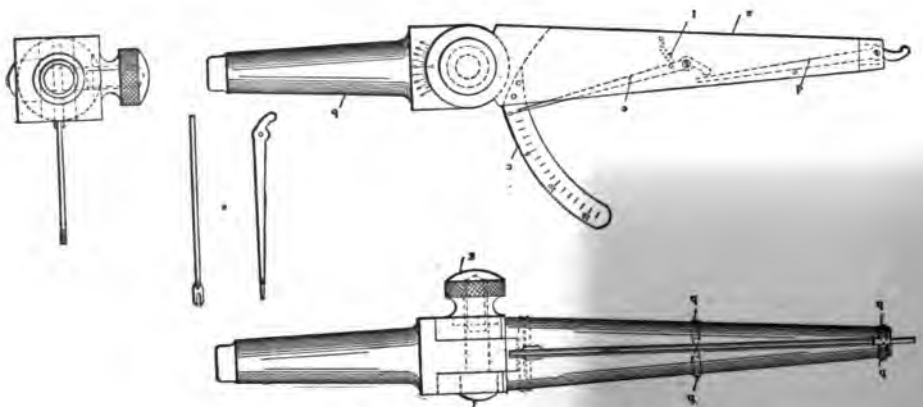


FIG. 14. — Indicator for Use on the Miller.

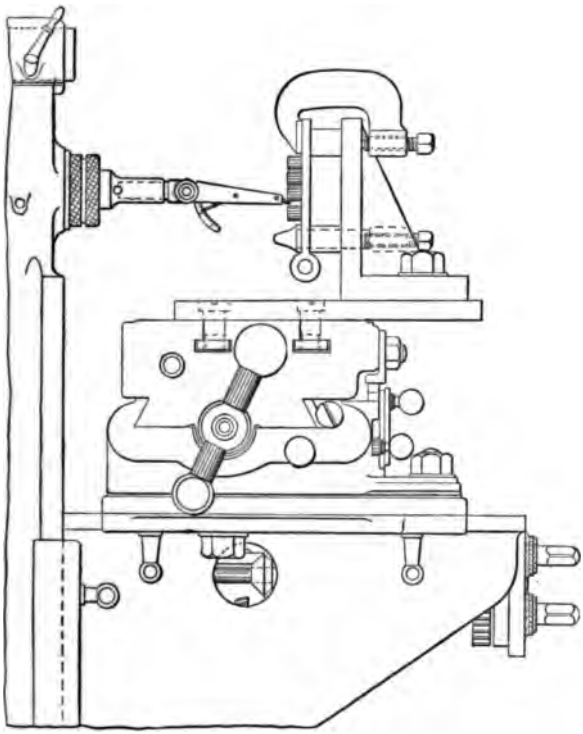


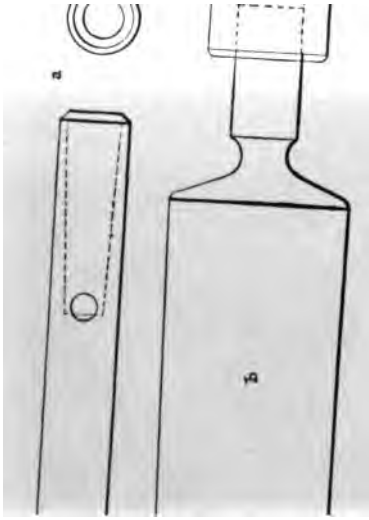
FIG. 15. — Work on the Miller.

tools in place of the indicator without disturbing the longitudinal position of the table, the tools being inserted by the use of the cross-feed screw.

The indicator is shown in Fig. 14. The shank *b* is fitted to a Brown & Sharpe small taper. On this shank is milled a tongue which fits into part *a*, and is graduated to facilitate setting the instrument to describe a circle of any diameter from 0 to 4 inches. When the zero mark on *a* is in line with a similar mark on *b* the point of the indicator lever which comes in contact with the work will revolve on the center. There are eight graduations on each side of zero, each line giving a $\frac{1}{4}$-inch movement. That is, to describe a $\frac{1}{2}$-inch circle the zero line on *a* would be set in line with the first line from the zero on *b*, and similarly the other figures on *b* denote the circle the point will describe. The tongue and groove joint is held firm by the nurled nut and bolt *g* and *i*. The body *a* is slotted through its center to receive the two levers *e* and *d*, which swing on small pivot screws *h* having 60-degree points. A small and delicate spiral spring *f* tends to hold lever *e* *to zero* on the graduated plate *c* and also gives

pressure against lever *d* which in turn acts on the work. A little stop-pin above lever *d* holds the levers in position when at rest. A detail sketch of lever *e* shows the index end to be forked to read against graduations on both sides of the arc plate *c*. This double graduation permits readings to be taken from either side, as the indicator turns over with the machine spindle. The indicator can be used to true up a hole as well as a projection, and it can also be used to good advantage in the drill press or lathe by placing the shank *b* into a round rod shown in Fig. 16 at *a*.

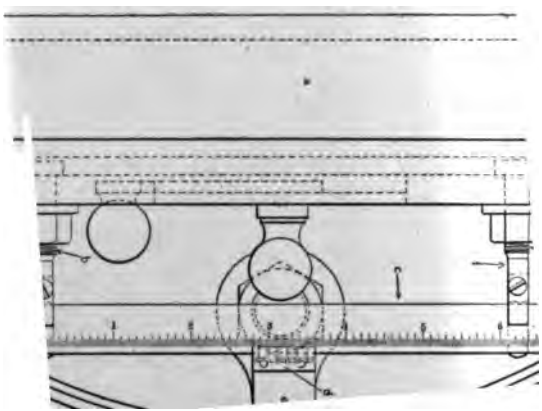
We have also seen another method in use for locating work on the milling machine, which, however, is not as accurate as the indicator. We refer to the arbor and bushing method, shown in Fig. 16, at *b*. The arbor has its end ground and lapped to the same size as the buttons, and a nurled ring is lapped out a nice sliding fit on the arbor. By placing the arbor in the machine spindle and bringing the jig button close to it and in line with it, so that the nurled ring will slip over the button, it is certain to



bring both arbor and button in line. The trouble with this method lies in the failure of the arbor to always run true with the spindle. Should a bit of dirt get between the arbor and spindle, as is often the case, or should the spindle hole not be dead true, the arbor would not be true with the spindle, and an error would result in locating the work.

Another good method that can be used for accurately locating distances on the milling machine is shown in Figs. 17 and 18. Accuracy is obtained by using a Brown & Sharpe vernier caliper beam and vernier plate, instead of the graduated dials. On the milling machine table *a* and into the T-slot which is intended for the feed-tripping studs two bolts marked *b* are placed. They project out beyond the nuts that hold them in position about 1¼ inches, this outer part having been turned to the size of the root of thread and part of it flatted off to act as a resting place for the vernier caliper beam *c*, which is held in position by two small straps and screws *f*.

The forging *g* is held in position by utilizing the forward bolt and nut *h*, that serve to bind



the swiveling part of machine. On the top end of *g* the adjustable block *e* is held by a dovetail milled in *g* and a slot and small binding bolt *i*. On this block *e* is secured the vernier plate *d*.

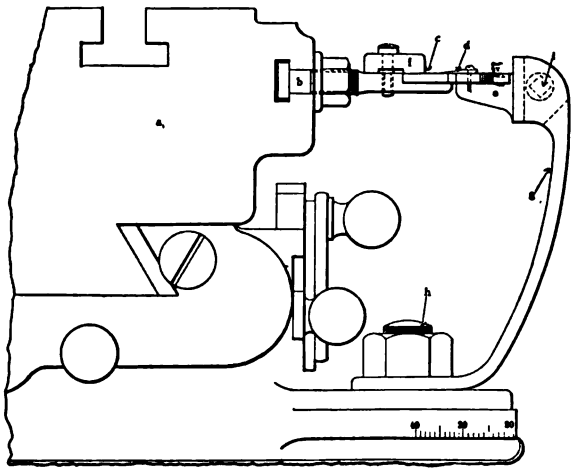


FIG. 18. — End View of Vernier Attached to the Miller.

As can readily be seen, by running the table to and fro and recording the measurements from the vernier, accurate measurements can be made. Accurate up-and-down measurements were made by a little extra device clamped to the column of

the machine and end measuring rods of such lengths as the job required, these rods being used between the knee of the machine and the part clamped on the column. One more little kink and this method is complete: By bending a piece of wire around *g* having a loop above to hold a magnifying glass, easy and accurate reading is obtained. This last named method is limited in range and accuracy by the length and accuracy of the vernier.

INDICATORS AS APPLIED TO MILLING MACHINES

WHILE the usefulness of the graduated, multiplying indicator as applied to lathe, planer and testing work is pretty generally understood, there are still many other operations in all departments of metal manufacture, where, by its use, work can be both facilitated and improved. Having experimented with very satisfactory results for the purpose of determining its actual value in a regular line of machine-tool milling, we will try and describe a few operations where it was used to advantage.

In Fig. 19 a freshly ground cutter is shown mounted on a lathe mandrel (previously tested), in a pair of Pratt & Whitney centers having an indicator attached, to determine if (when revolving) all the teeth are "even" or concentric. This is especially useful when applied to machine-

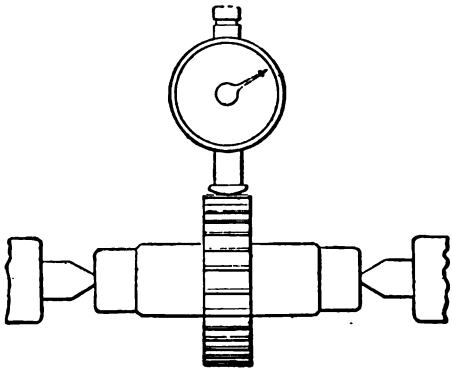


FIG. 19. — Testing a Cutter.

relieved cutters. Fig. 20 shows a rig for holding the indicator while truing a cutter when both cutter and arbor are in place on the machine.

Arbors are ground from .003 to .005 inch smaller than the sizes of standard holes in cutters to permit the shifting of the cutters when truing.

Indicators having flat shanks or stems are most convenient when they are used only occasionally, or on different machines, as they then can be

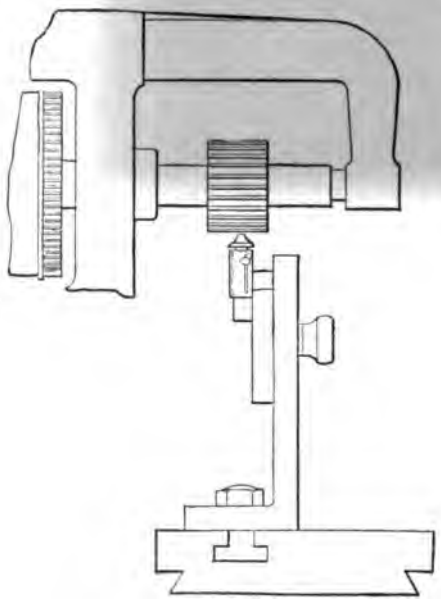


FIG. 20. — Rig for Holding Indicator.

readily clamped to fixture, work or table, and in many positions. When they can be suspended from overhanging arm, as in Fig. 23, or

column, those with round shanks or stems are best.

Fig. 21 shows how single or double-ended facing and boring cutters in boring-bars are tested, both for diameter of hole to be bored and for truth, displacing the old cut-and-try method by one absolutely certain.

Alinement of bar with cross-slide is secured as shown in Fig. 22, by turning over the arm on its axis, as shown (exaggerated) by dotted lines at *B*, Fig. 23. Fig. 23 shows how the depth of slots or grooves in repetition work, such as clutches, bevel gears and keyways, may be quickly gaged without "touching" each piece with the cutter. This is also useful in setting center line of head and tail-stock (when vertical adjustment is provided) parallel with travel of table horizontally, and laterally, if table swivels.

Anticipating objections which may be made to having arbors smaller than holes in cutters on account of shifting, we will say that, with a 4-pitch gear cutter having a hole .01 inch larger than arbor, we milled 50 inches of steel ½ inch deep at a speed of 37 feet per minute and

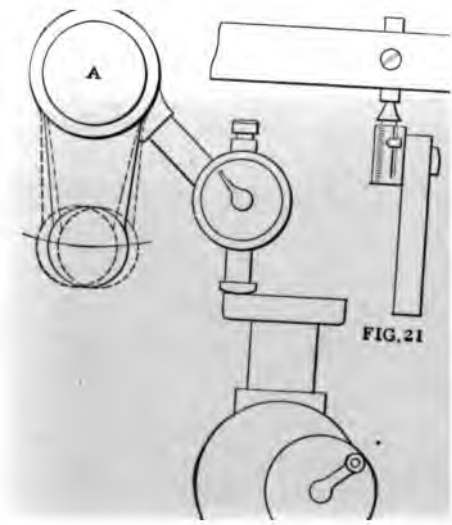


FIG. 21

inch table feed per revolution, and again, 15 inches ½ inch deep at a speed of 41 feet and .150 inch feed per revolution without shifting cutter; also, the arbor was not splined. This forces the conclusion that when arbor collars are properly proportioned and in good condition they will not slip unless abused or overloaded, also that keyways, for the most part, are unnecessary. Cutters properly ground, running true, with every tooth doing its proper share of work, last longer, do better work, and can be crowded harder than when any of these essentials are missing. We should state that in truing we established a limit of error of .002 inch, though .001 inch is easily attainable.

TESTING MILLING CUTTER ARBORS

SOME shops often have trouble with the cutters on milling machines, because they are not sufficiently true upon their axes of rotation, although each cutter in the shop may remain upon the same arbor and is fixed with hydraulic pressure.

To avoid this trouble a way has been found to

set up on the taper shank of the arbor the piece *B*, Fig. 24, and so when the cutter is sharpened one can see immediately if *B* is true, with the axis *C D*, as it will be if the cutter arbor is not bent.

The cutter is then sharpened between the centers *E D* of the grinding machine.

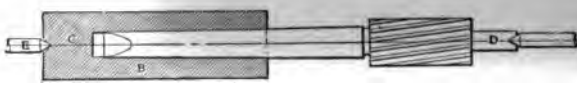


FIG. 24. — Testing Cutter Arbor.

A SPECIAL RIG FOR CUTTING BEVEL GEARS ON THE MILLING MACHINE

THE device in Figs. 25 and 26 illustrates a convenient and practically accurate method of cutting bevel and miter gears on a milling machine. It is a modification of a similar device which we have seen in use in other shops.

A gear planer is undoubtedly the only tool that will produce a theoretically correct cone gear, but since this tool is of necessity an expensive one it happens that numerous shops are not equipped therewith.

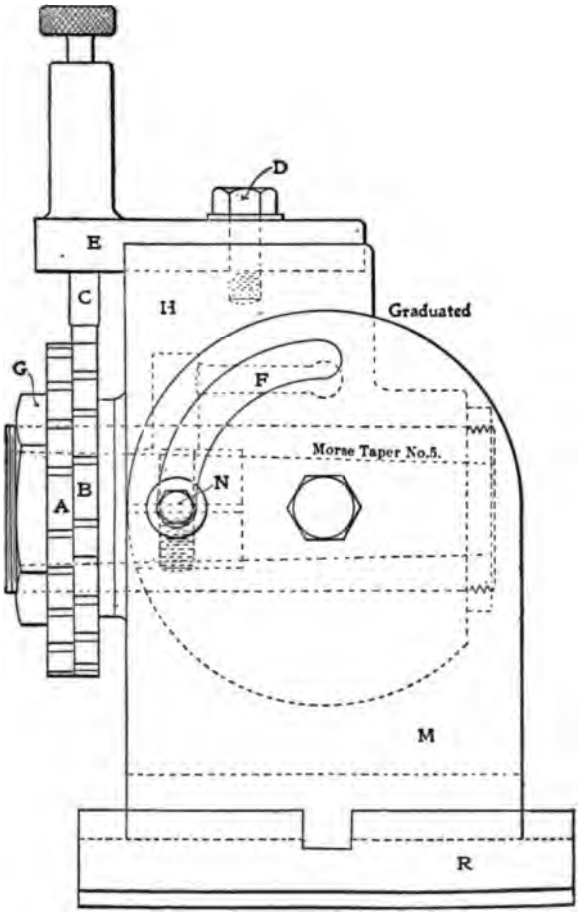


FIG. 25. — Fixture for Cutting Bevel Gears on the Miller.

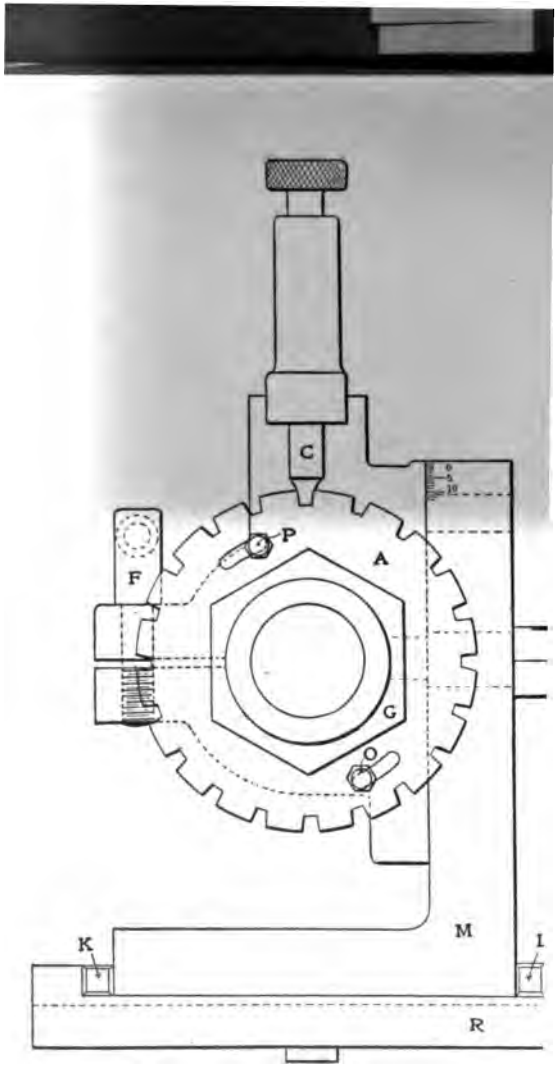


FIG. 26. — Fixtures for Cutting Bevel Gears on the

This device has given absolute satisfaction and by its use gears have been produced second only to those cut on gear planers.

The principle upon which this device is based is the same as that of an ordinary dividing head. Referring to Fig. 25, which is a side view, and to Fig. 26, which is an end view, piece *R* is a base plate which carries an angle plate *M*. The piece *R* has a tongue fitted into the tee slot of the platen, which insures perfect alinement. The angle plate *M* is just 1 inch narrower than the inside measurement of plate *R*, the space on each side being filled up by two pieces of ½ x ½ inch steel, which brings the head central.

The operation is briefly as follows: Place a center in the dividing head, center the proper cutter for the gear which is to be cut, and set index ring on cross-slide screw to read zero.

The two index plates *A* and *B* are then adjusted, the notches in one being advanced beyond those of the other plate, suitable slots *P* and binding screws *O* being provided for this. This advancement we will term the roll and it must be determined by experiment. The gear blank

is then put on a taper plug held in the dividing head spindle, the pull pin *C* is placed in one of the notches of the inner plate *B* and the cross-slide of the milling machine is moved by an amount equal to one-half the thickness of the cutter on the pitch line. The setting of the gear to the proper cone angle is readily accomplished by observing the graduations on the top of plate *M*. The cutter is next set so that it touches the gear blank on its largest diameter, the knee of the machine is adjusted to the proper depth of tooth and the machine is ready to cut all around, using the index plate *A*. Having cut once around the pull pin is adjusted by means of slot and binding screw *D* so that it comes in line with index plate *B*, and the cross-slide is now moved out from zero the same amount that it was moved in during the first operation and the gear is cut all around as before, using the index plate *B*. If the gear teeth are too thick at the pitch line, give the index plates more or less roll, as the case may be. Having determined the proper roll, the two index plates can be doweled together to preserve the adjustment for future use.

Instead of moving the cross-slide in and out for every gear, the blocks *K* and *L* may serve the useful purpose of positive stops. For this purpose reduce these pieces the number of thousandths that the cross-slide is to be moved, which can be read from the index collar on the screw. If the cross-slide is placed on zero and one of the blocks is interposed between ledge on plate *R* and the angle plate *M*, and the angle plate *M* is moved up against same, the same result is obtained as by using the cross-slide of the machine, while all danger of mistakes due to incorrect reading of the micrometer dial is eliminated.

TABLE FOR SETTING MILLER WHEN CUTTING WORM WHEELS

TABLE 2 gives the angles at which to set the milling-machine table for cutting worm wheels. This table will be of assistance to some of those engaged at the practical end of the business. It is the usual shop method to lay off the lines and then find the angle with the protractor. The table gets over this, as the diameters and threads can be used direct in finding the angle.

TABLE II. — ANGLES FOR SETTING MILLER TABLE FOR CUTTING WORM WHEELS

Diameter of Worm on Pitch Circle in Inches	THREADS PER INCH ON WORM									
	8	7	6	5	4	3	2½	2	1½	1
1	2°-16′	2°-36′	3°-2′	3°-39′	4°-33′	6°-5′	7°-18′			
1¼	1°-50′	2°-6′	2°-26′	2°-54′	3°-39′	4°-52′	5°-50′			
1½	1°-31′	1°-44′	2°-1′	2°-26′	3°-2′	4°-3′	4°-52′	6°-5′		
1¾	1°-18′	1°-30′	1°-44′	2°-6′	2°-36′	3°-28′	4°-12′	5°-12′		
2	1°-8′	1°-18′	1°-31′	1°-50′	2°-16′	3°-2′	3°-39′	4° 34′	6°-5′	
2¼	1°-1′	1°-9′	1°-21′	1°-37′	2°-1′	2°-41′	3°-15′	4°-2′	5°-22′	
2½	55′	1°-3′	1°-13′	1°-28′	1°-50′	2°-26′	2°-54′	3° 39′	4°-52′	7°-18′
2¾	50′	54′	1°-7′	1°-20′	1°-40′	2°-13′	2°-40′	3°-20′	4° 27′	6°-40′
3	46′	52′	1°-2′	1°-13′	1°-31′	2°-1′	2°-26′	3°-2′	4°-2′	6°-5′
3¼	42′	48′	56′	1°-7′	1°-24′	1°-52′	2°-14′	2°-48′	3°-44′	5°-36′
3½	39′	45′	52′	1°-3′	1°-18′	1°-44′	2°-6′	2°-36′	3°-28′	5°-12′
3¾	37′	42′	48′	59′	1°-13′	1°-37′	1°-57′	2°-26′	3°-15′	4°-52′
4	34′	39′	46′	55′	1°-8′	1°-31′	1°-50′	2°-16′	3°-2′	4°-34′
4¼	32′	37′	43′	51′	1°-4′	1°-25′	1°-42′	2°-8′	2°-51′	4°-16′
4½	30′	35′	40′	48′	1°-2′	1°-21′	1°-37′	2°-1′	2°-41′	4°-2′
4¾	29′	33′	38′	46′	58′	1°-17′	1°-33′	1°-56′	2°-35′	3°-52′
5	28′	31′	37′	44′	55′	1°-13′	1°-28′	1°-50′	2°-26′	3°-38′
5¼	26′	30′	35′	42′	52′	1°-9′	1°-23′	1°-44′	2°-19′	3°-28′
5½	25′	29′	33′	40′	50′	1°-7′	1°-20′	1°-40′	2°-13′	3°-20′
5¾	24′	27′	32′	38′	48′	1°-4′	1°-17′	1°-36′	2°-8′	3°-12′
6	23′	26′	30′	37′	46′	1°-2′	1°-13′	1°-31′	2°-1′	3°-2′
6¼	22′	25′	29′	35′	44′	59′	1°-11′	1°-28′	1°-57′	2°-54′
6½	21′	24′	28′	34′	42′	56′	1°-7′	1°-24′	1°-52′	2°-48′
6¾	20′	23′	27′	32′	40′	54′	1°-4′	1°-21′	1°-47′	2°-41′
7	19′	22′	26′	31′	39′	52′	1°-3′	1°-18′	1°-44′	2°-36′
7¼			25′	30′	38′	51′	1°-1′	1° 16′	1°-41′	2°-32′
7½			24′	29′	37′	48′	59′	1°-13′	1°-37′	2°-26′
7¾				28′	35′	47′	56′	1°-10′	1°-33′	2°-20′
8				28′	34′	46′	55′	1°-8′	1°-31′	2°-16′

SHAPE OF SAW TOOTH FOR GERMAN SILVER

FIG. 27 shows a cutter used in milling german silver. Those who have worked that alloy know how hard it is to work in almost any form. The cutter is an ordinary stock cutter.

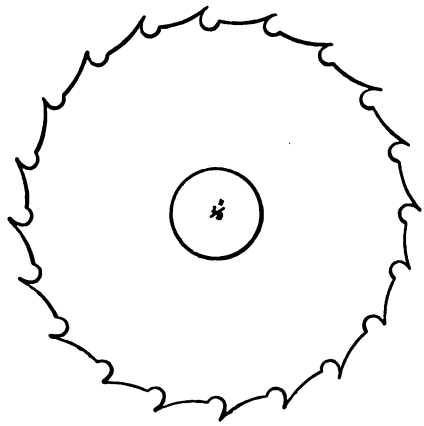


FIG. 27. — Saw for German Silver.

In making the cutter every other tooth is ground down. The grooves are made with a narrow wheel with the periphery made round. A cutter of this form cut a .025-inch slot

down one side of over 2000 pieces of German silver .10 diameter by 2 inches long, while the ordinary cutter would cut only a few hundred.

SAWING COPPER

It is well known that there are difficulties in the way of sawing copper, although some people who sell saws will advertise them as suitable for steel, brass, copper, etc., as though there were no difference.

Whenever a cutting tool which will satisfactorily cut one material fails to cut another material, the cause must be sought in the properties of the material to be cut. It is not of much good trying different sorts of lubricants. Indeed, there is reason to believe that a lubricant may enable a saw to fail that has proved capable of cutting dry. When saws fail to cut copper they appear to strip whole teeth and to break right across, or large pieces come out of the saw disk. Copper is a very tough metal to begin with, and is well known for the difficulty in turning it,

which is effected at a high speed with a fine-pointed tool. In taking a cut from a copper surface, the shaving does not readily break, but it pulls up more copper, tearing this out in irregular little lumps from the surface behind the chip. The chip fails to get away. It travels down the face of the tooth, fills the whole tooth space and finally forms so powerful an obstruction to progress as to break a tooth, or, by the combined action of several teeth, to break the saw. Where the teeth are radial on their advancing faces, this gives the sharp point every chance of tearing up the floor of the cut, the saw teeth endeavoring to draw themselves into the metal.

The sketch, Fig. 28, shows how the teeth ought to be made. The face of the tooth is not a radial line, but slopes forward at the base at such an angle as to touch a circle of about $\frac{7}{8}$-inch diameter. If this slope-fronted tooth be considered, it will be perceived that its action is to push the copper away from the saw if possible, but, as there is a feed on, something has to give way and the copper is removed in small chips which do not now tear up the floor of the cut.

The sloping form of tooth strokes down the copper and only the desired cut is removed. In plain words, the saw does not dig in.

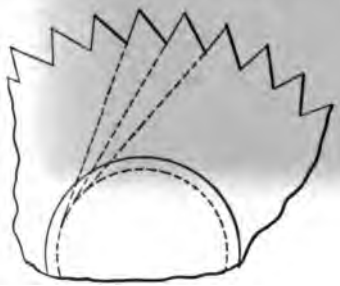


FIG. 28. — Saw for Copper.

WHY THE SAW TEETH BROKE

ONCE when engaged in some experimental work for an inventive individual it happened that we needed about a thousand small pieces which were practically segments of an 18-inch circle, and $\frac{5}{8}$ inch thick. These were sawed from a ring by regular slitting saws, but one after the other of the saws broke until they were ordered by the dozen.

We laid it to the arbor running out of true, to the play in the bearings, to the vibration of the

building, and tried to correct as many of these possible faults as we could, but to no purpose. They kept on breaking just the same. Flooding them with lubrication made no difference.

We changed speeds, feeds and everything else that was changeable, but they broke just as frequently as before.

Just at this time we thought of trying one more thing, so we took a saw to the tool-grinder, and holding it against the side of the wheel, ground nearly half of the tooth away on one side, and then the next tooth on the opposite side, grinding it all around that way.

We had found the cause.

The chips were now only about half the width of the saw, and as they could turn around in the saw cut they found an easy egress. Needless to say the job thereafter went much quicker, and no more saws were broken.

BORING TOOL-HOLDERS FOR THE MILLING MACHINE

ALL toolmakers, and machinists who are familiar with the universal milling machine, know

that a hole cannot be drilled and reamed with one (through no fault of the machine), with any certainty of its being accurate. Drills are liable to spring and run off in an erratic and aggravating manner, even in a lathe or drill press, as we all know to our sorrow.

This device, Fig. 29, is designed to correct this difficulty, and we have drilled and bored holes from ¼ inch upward in jigs and fixtures, and found them all that was required. The body of the tool consists of a casting *a*, bored and chased to fit the spindle. The rest of the mechanism consists of nothing more than the good old every-day slide rest *b*, with a boss cast on it, which carries the tool *c* and a good substiantal set screw to hold it, which is adjusted by means of the screw *d* and the nut *e*, the former being held in position by the plates *f* and *g*, the latter recessed in the slide *b* and held by the flat-head screws.

The tool is used as follows: We have, for example, a drill jig to make, with four bushings in a circle, equidistant from each other. We first swing the jig up on the face-plate, using the

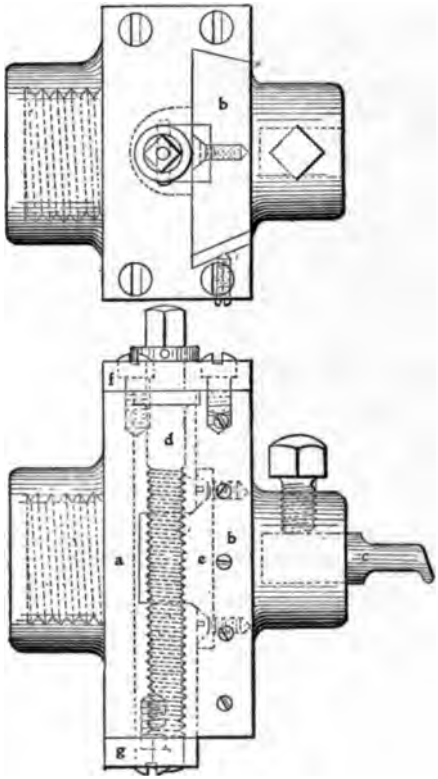


FIG. 29. — Boring Tool for Milling Machine.

index head, and drill the holes carefully by indexing them, leaving the usual amount to bore out to finish. We then screw the boring fixture in place on the spindle and bore the holes to size with the tool *c*, adjusting the cut by means of the screw *d*. When we are around again the holes are as accurate as the index head will make them.

A BORING-TOOL HOLDER WITH MICROMETER ADJUSTMENT

THE boring-tool chuck shown in Fig. 30 will appeal to first-class toolmakers who have experience in locating and boring holes for bushings in drilling jigs and fixtures, on vertical milling machines. It is a tool for saving time and for doing accurate work, and will earn its cost within a short space of time in shops where much jig and fixture work is done. At the present time, in many tool rooms, the boring tools are held in ordinary drill chucks, which necessitates a repeated bending of them for the successive cuts until the required diameter of bore is attained.

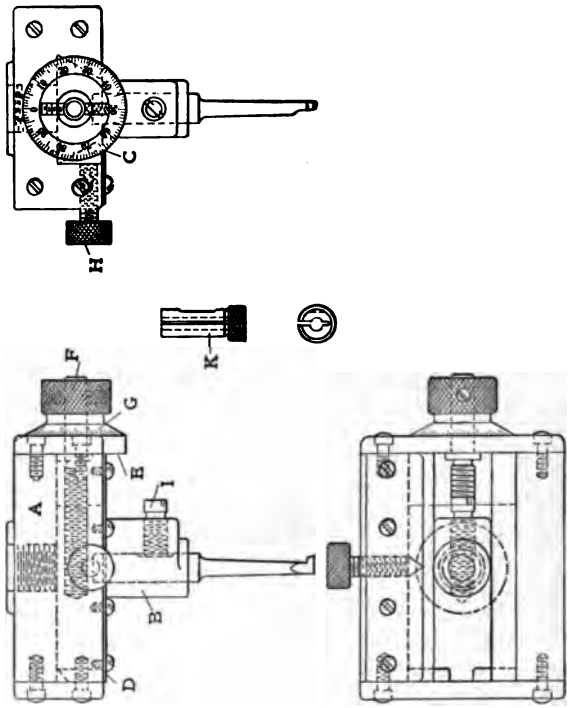


FIG. 30. — Boring Tool with Fine Adjustment.

The body *A* of the chuck is bored and threaded to fit a milling-machine arbor of the kind used for holding end mills with threaded holes. The slide is made with a projection *B* containing the hole and the set-screw *I* for holding the boring tools. When the slide is brought up against the stop plate *D* the hole is central for carrying locating plugs and drills for starting the bore. Drills smaller than the hole in the projection are held with split bushings as shown at *K*. The slide is moved by a twenty-thread screw *F*, to which a disk *G* is attached, graduated in 100 divisions, to record cuts in 0.001 inch in the diameter of the bore. In the nurled portion of the disk are two headless set-screws with 60-degree points, which engage in two offset holes in the shank of the slide-moving screw for taking up the wear between the disk and the thrust plate *E*. The triangular gib *C* is held in place with a thin springy plate fastened to the under side of the body. This plate is made with a slight curve running lengthwise, of sufficient tension to press the gib upward against the slide, cause friction on it to prevent it from moving

too freely, and to insure an accurate setting for a cut when the clamping screw *H* is loose. The hole in the gib into which the 60-degree point of the clamping screw enters, is offset downward from the center of the screw, so that when the screw is tightened the gib is forced upward to lock the slide in place.

ANOTHER BORING-TOOL HOLDER FOR THE MILLER

FIG. 31 shows another very convenient attachment to a jobbing shop or tool-room milling machine. It is designed to hold a regular round boring bar with inserted tool held by set-screw or other means.

A is a casting which is threaded at one end to fit the nose of the milling-machine spindle and bored at the other end to receive piece *B*. The threaded end of *A* and the end into which *B* fits are eccentric to each other about $\frac{1}{8}$ inch. *A* is split from the front end up to the threaded part and has a binding screw *C* for securing *B* in position. The boring bar is carried by *B* (which

is graduated on the outside) and is secured by set-in holder *B* and allowed to project the required distance, when the inserted cutter may be set to bore a hole of approximately right diameter, and further adjustment for cuts made by turning *B* in *A*. Several bushings may be

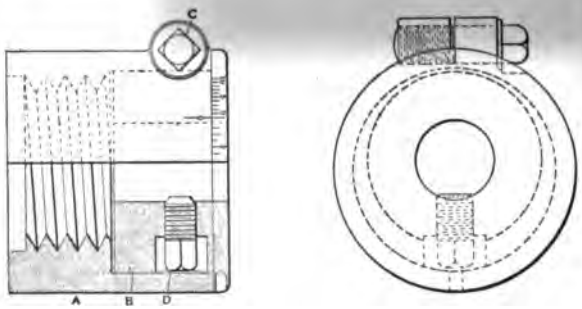


FIG. 31. — Another Boring Tool.

made for part *B* to accommodate different diameters of bars and all bars made comparatively long, as any length not required on a particular job may extend back into the hole in the milling-machine spindle.

This tool gives a quick and fine adjustment for cut and has the further merit of being inexpensive.

A HIGH-SPEED MILLING ATTACHMENT

FIG. 32 shows a high-speed milling attachment for doing small end-mill work. Most milling-machine manufacturers supply an attachment for this purpose, the spindle of which has its bearing within a bushing fitted into the taper

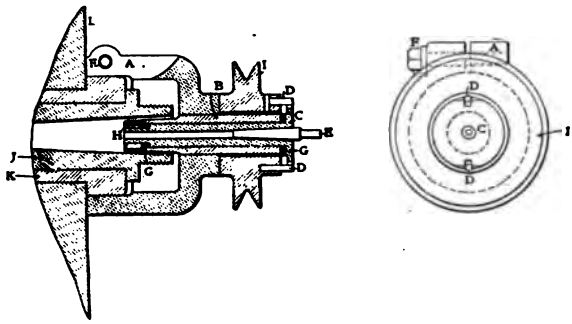


FIG. 32. — **High-Speed Milling Attachment.**

of the milling-machine spindle. In the device shown the member which forms a bearing for the high-speed spindle does not revolve. It is of course necessary to revolve the milling-machine spindle to obtain a power feed.

L is the column of the milling machine, *K* the

front bearing. Gray-iron support *A* is fitted over bearing *K* and is split and clamped to it by screw *F*. Support *A* is also bored to receive a hardened, ground and lapped tool-steel sleeve *B*, which is reduced below the size of the taper of milling-machine spindle *J* and extends within it to provide a sufficiently long bearing without an unusual overhang. The high-speed milling spindle *C* is of hardened tool steel, ground and lapped and fitted to sleeve *B*. Spindle *C* is tapered to fit and receive the mills *E*, and is flanged at outer end and provided with nut *H* at inner end for taking up end play. Fiber washers *G* serve to oppose thrust. The sheave pulley *I* is bronze bushed and is fitted loosely over the sleeve *B* and contains pins *D* projecting from its hub into the slots milled through the flange of spindle *C* to act as drivers.

It will be seen that the unevenness of the belt pull will not affect the spindle *C*, which has nothing touching it but drivers *D*. This device is intended to be driven by an electrical grinder, which is attached to the overhanging arm and supplied with a sheave pulley in place of the

usual emery wheel. It makes another new use for that already versatile and handy little device.

ANOTHER HIGH-SPEED MILLING ATTACHMENT

FIG. 33 is a high-speed milling attachment

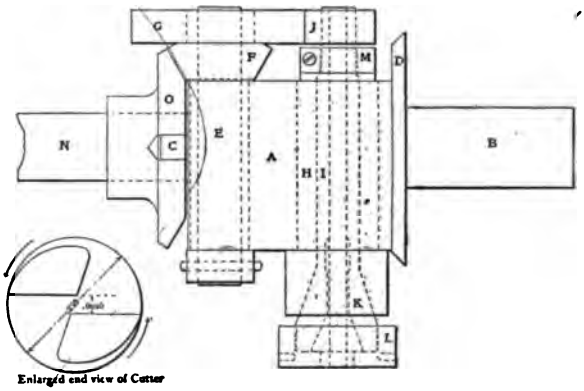


FIG. 33. — Another High-Speed Milling Attachment.

for using end mills in either a vertical or horizontal position, which was designed and made for a Kempsmith universal miller. The body *A* is in one piece of mild steel. We took a piece of 4-inch round steel 6 inches long, turned the

shank B $1\frac{3}{16}$ inches diameter by $2\frac{1}{2}$ inches long and the tit C $\frac{3}{8}$ inch diameter and $\frac{3}{8}$ inch long, also turning the beveled ring D. It was then mounted on the miller centers, where the top and bottom were faced 1 and $1\frac{1}{2}$ inches from the center line, respectively, making it $2\frac{1}{2}$ inches thick. The other two sides were left untouched. Then without removing it from the center a $\frac{7}{8}$-inch hole was bored close to the rear end and another hole $1\frac{3}{4}$ inches nearer the shank, and the same diameter as the latter, *i.e.*, $1\frac{3}{16}$ inches, for a reason that will appear later. The $\frac{7}{8}$-inch hole was bushed with bronze to take a $\frac{5}{8}$-inch shaft E, which carries an 18-tooth bevel pinion F and a 40-tooth 16-pitch gear G. In the $1\frac{3}{16}$ inch hole the gray-iron sleeve H was made a light driving fit, and clamped with two cotters. This sleeve is a bearing for the tool-steel spindle I, which has a .260-inch hole clear through, and an 18-tooth pinion J keyed on the upper end and meshing with G, while at the lower end is fitted the split-collet chuck K, operated by means of the threaded collar L. M is a split threaded collar *to take up slack* and wear, and has a fiber washer

under it. Ring *D* is divided in degrees. *N* is an arbor fitted to the main spindle and carrying the 36-tooth bevel gear *O*. Tit *C* is a running fit in the end of *N*.

To use the attachment insert *B* in the hole of the overhanging arm after removing the arbor bushing, locate positively by means of the tit *C*, swing around to the angle desired, either vertical or otherwise, and then clamp *B*. If it is desired to use the cutter in the same plane as the main spindle, take out the sleeve *H* bodily, and clamp it in the arm, swing it sufficiently out of the vertical to mesh *J* with an 80-tooth gear fitted on the nose of the main spindle, and clamp the arm. We find it surprisingly rigid, and experience no difficulty in cutting ¼-inch keyways ⅜ inch deep in machine steel in one cut at 5 inches per minute traverse.

We do not use an ordinary end mill, but a cotter mill, made as follows: Taking a piece of ¼-inch drill rod, put a $\frac{1}{16}$-inch saw cut $\frac{3}{16}$ inch deep across the end; file a groove each side, at an angle, to give a shearing cut; back off and harden, drawing to a very light straw. This form of

cutter is hard to beat for cutting "blind" keyways and similar work, as it can be run into the solid to full depth and then fed along. It cuts very "greedily" and never chokes with chips. The enlarged end view shows there is plenty of room for the chips. Also, it is cheap and easily made.

A SLOT-MILLING RIG

A NUMBER of slotted guide plates were taken, along with other machine parts, on a contract for some good customers, who knew enough to keep the easy work and job out the more difficult parts. When the specifications reached the foreman who, on the one side, never made stuff cheap enough and, on the other, was responsible for all delays, poor work and incidental differences between the shop and their customers, he pondered long and earnestly on the apparent problem of how to put a square-edged, smooth slot, $\frac{11}{16}$ by $5\frac{1}{2}$ inches, in gray-iron plates $\frac{3}{4}$-inch thick — and 2000 of them.

Meeting the "Dictator," who qualified for that

title in more ways than by mere daily conversation with his stenographer, he said, "Mr. W., how do you suppose I'm going to put these slots in and have the cost anywhere in reason?" "Oh, those! Why, drill them or plane them or chip them, or any way you prefer, just so long as they are made as called for. I don't care how you do them; but bear it in mind, that you've got to get those out of here in sixty days from day before yesterday. I figured a man could do about forty of those a day, and that would be fifty days for the lot."

With these reassuring remarks the "Dictator" retired to the office to "figure" how many a day a man could make of something else, and the foreman said things to himself that can be expected when a man who wears the blue and white stripes is subjected to a tensile strain far beyond the factor of safety.

Two more days of desperation and the device shown in Fig. 34 was produced on sundry envelope backs, and perfected by chalk work on available castings. The back gear on the spindle of a plain miller was removed and a crank pin

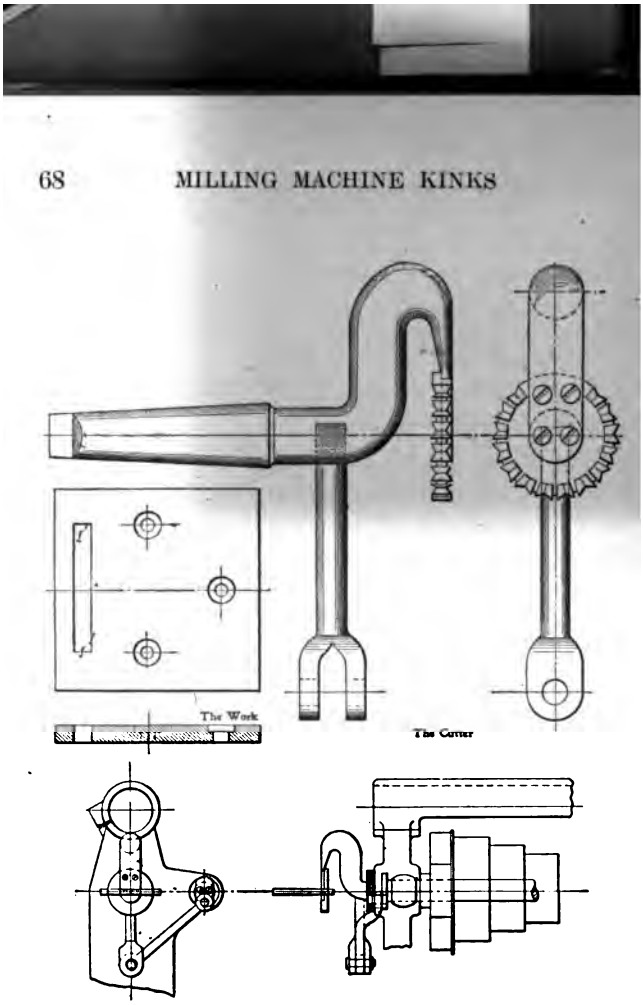
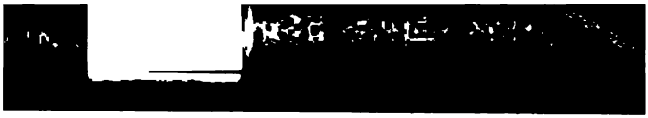


FIG. 34. — A Slot-Milling Arrangement.



attached to the end of a shaft on which a gear corresponding to the quill gear was fastened gave the required rocking motion to the arm carrying the cutter. The cutter, made with teeth to cut both ways, was applied in the manner shown and worked about like a file. It got the work out at the rate of a hundred a day.

BORING AN ELLIPSE ON THE MILLING MACHINE

About two years ago we happened to place an order for an elliptical punch and die with a supposed up-to-date toolmaking shop. We asked these people to produce an ellipse theoretically perfect, and after giving the two dimensions were assured that our request would be granted.

About a week later we again visited the shop and found the die just finished — that is, it was filed up and polished — but we could not reconcile ourselves to the alleged fact that the filed hole was an ellipse. It was rather a bungling attempt at one, and had the usual four-cornered

appearance of those laid off with the dividers. What should be done? The boss argued that the curve of a real ellipse was one quite too delicate for the human eye to design, and especially to file out, and subsequently offered to construct an ellipse engine after the manner of the ellipsograph for $75, and use it to bore out the die.

The idea was not bad, but the extra item of $75 and the annoying delay were enough to set one to thinking.

We started to size up the untried powers of the lathe and the universal milling machine, and in ten minutes hit upon a way to bore out the die so that it would come theoretically true. The stampings were to act as a cam to reconvert the desired elliptical shape into a true circle by means of a lever, and *vice versa*. Not only could we rig up their compound-rest lathe to do this work, but the milling machine as well, by using nothing but a boring bar already at hand.

Without resorting to trigonometry we drew a diagram as in Fig. 35, in which *A B* was the short

diameter and *E D* the long diameter. Line *A B* was first drawn, and then the dividers were set

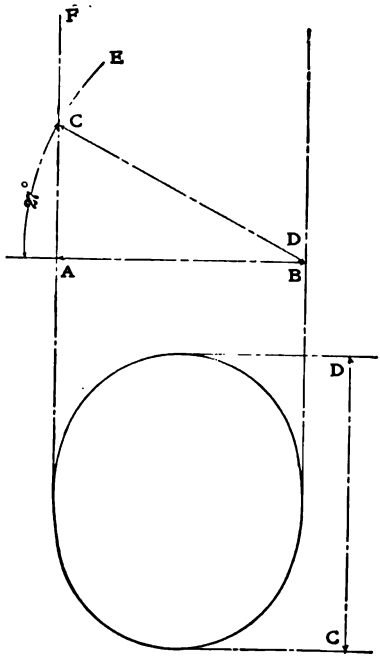


FIG. 35. — The Ellipse Diagram.

to the length *C D*, or the length of the ellipse. Finding a center in the line *A B*, the arc *E* was drawn; and by carefully noting the intersecting

degrees.

As applied to the milling machine th

operandi" was as follows: The vertica
ment was put on in the usual way, an
end boring bar inserted. This was s
angle of 27 degrees, as shown in Fig.
double-edged pointed tool *A*, Fig.
put in the boring bar, and set long en
reach to the largest diameter of the
llipse.

The die plate was clamped in the vise,
quare, as at *B*, Fig. 36, after having
ie point of the tool *A* with the inaccur
the die. The plat...

the performance caused in that shop was amusing. Everyone abandoned his work to look on, while the management said nothing, for at least the first hour.

By employing this scheme ellipses of all ratios may be bored as well as turned, as in the case of

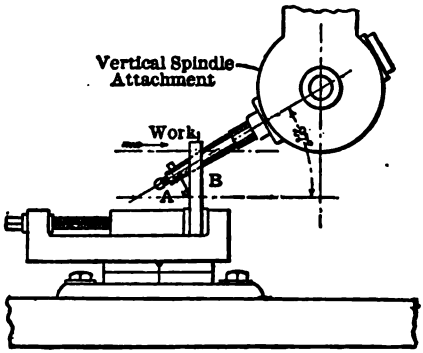


FIG. 36. — Boring the Ellipse.

cutting elliptical bars; although in the case of boring, the greater the ratio the more limited is the depth which can be bored before the bar will strike the plate, and thus stop the work. To bore thick plates the spindle may be swung over to the opposite side and thus made to bore in

process we made a small cast-iron
some of the stock left, to indicate
of the tool, and have handed it to
a hundred mechanics and drafts
mechanical puzzle. It was in
explained.

SUPPORTS FOR TOOL W

MANY devices so familiar in some
be taken as a matter of course ma
places be looked upon as novelties, by
members of the trade at least, and

dinally from the lower end to about the head. A V-shaped groove is cut from the lower end to the head and into the drill hole, the groove having an included angle of about 60 degrees and taking the point of a special set-screw tapped into the base block. It is evident that this screw will expand the pin when set against it, and hold it where required.

The head of the pin offers an easy means of lifting the pin into contact with the work. The hole should be of rather large diameter to allow the pin to spring open easily, and the screw should bear heavily near the outer edge of the groove for the same reason.

Fig. 38 shows another form of a device for the same purpose. It is simply a pin with a head as before secured in the desired position by a binding screw which closes the split block, as shown. In either device it is essential to have a good hole in the block and a good fit for the pin if maximum holding power and ease of tightening are desired. Any suitable block for the base may be used, or the pin may often be incorporated in a fixture for holding the work. In the

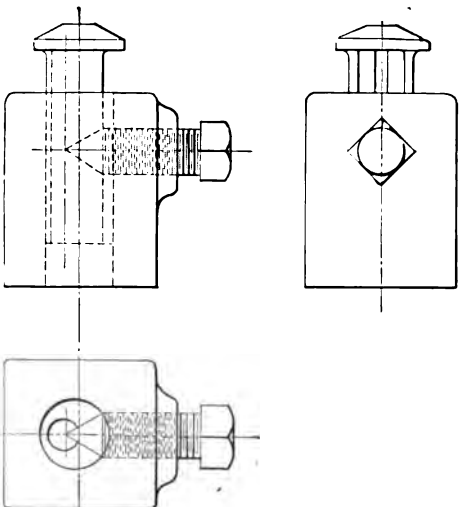


FIG. 37

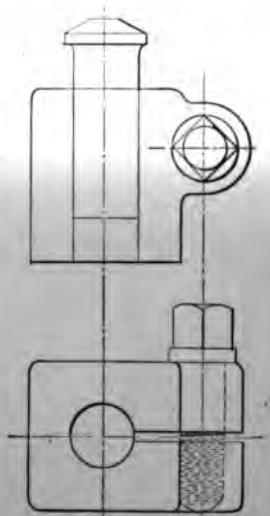


FIG. 38

Supports for Tool Work.

latter case Fig. 37 may be the more useful, as it is often desirable to put a support where a saw cut cannot be made or is not wanted. With either of these devices the springing tendency found in jack-screws and wedges is avoided.

FIXTURE FOR MILLING TAPS, REAMERS, ETC.

We have found a fixture made like the sketch, Fig. 39, to be very handy, quick and reliable. The working parts are all hardened, the spindle

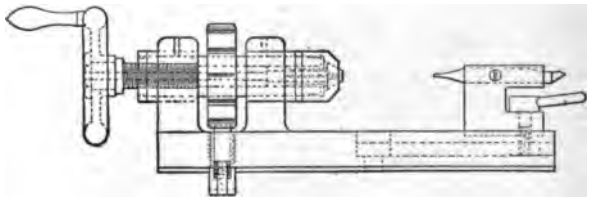


Fig. 39. — Fixture for Milling Taps and Reamers.

being ground and bearings lapped. The working of the chuck is easily understood. By turning the crank wheel the spring chuck is forced against

the hood on the end of the spindle, clamping the tap to be milled. The index wheel, fastened to the spindle, has twelve 90-degree notches cut about $\frac{1}{8}$ inch deep. With this we can cut 12, 6, 4, 3 or 2 teeth, and the spring shells will take as large as a $\frac{5}{16}$ inch tap.

To index it is only necessary to turn the crank wheel as if to tighten the chuck, and the abrupt bevel on the index pin permits the turning of the index spindle; the click of the index pin when it strikes the notch in index plate is sufficient for counting when spacing. The tail center is reversible, one end having a female and the other a male center. A hole through the clamping screw allows the milling of long shank tools.

TEMPLET MILLING

In "templet" milling the upper edge of the templet gives the bottom line of the groove to be milled.

A tin disk of the diameter of the cutter is placed on the arbor over the templet as shown in Fig. 40. When feeding the disk is made to

barely touch the templet, which is clamped or pinned to the block.

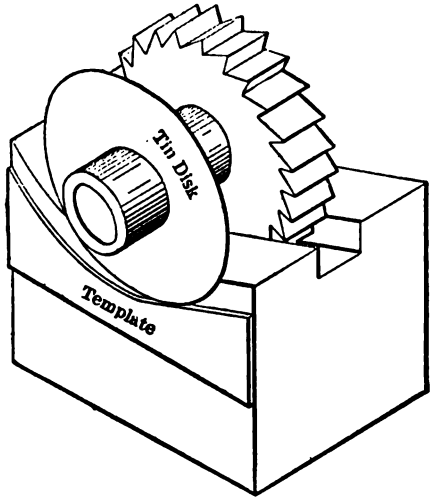


FIG. 40. — Templet Milling.

HOW TO KEEP THE DIVIDING HEAD BOLTS FROM TURNING

FIG. 41 shows a method for preventing the bolts of the dividing head of the milling machine from turning around, thus making it comparatively easy to place that piece of apparatus on

the platen. *A* is a piece of $\frac{3}{16}$-inch round steel rod driven tight in one bolt head, and a free fit in the other, the head in which it fits tight being the first one to enter the T-slot of the platen when putting on the index head.

This device has been in constant use about ten years, and no fault has been found with its operation. The nice point about it is its simplicity, the few minutes spent in its original

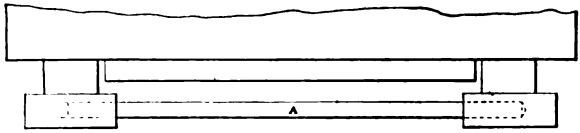


FIG. 41. — Scheme to Prevent the Dividing Head Bolts Turning.

construction being saved many times over in its use. The $\frac{3}{16}$-inch holes in the bolt heads do not seem to weaken them, as this index head has been subjected to rather rough usage at times without the bolts showing any signs of weakness. This is an excellent way in which to fix up a machine of the old type; perhaps in later models the makers may provide against the inconvenience of a bolt head twisting around.

AN IMPROVISED MEASURING MACHINE

THE demand for accurate measurements is growing constantly, and, in general, adequate means are provided, but occasionally one has to make the best use of what he has, and since making some measurements with a milling machine, we are satisfied, unless extreme accuracy is required, that it may be successfully used as a measuring machine, if standard scales or rods are used with it of about the length of the work to be gaged. As an illustration of what can be done in this line, we will describe how some "pointer templets" were gaged.

The templets are really depth gages to turn the grooves in pipe rolls by. One is shown lying on the milling-machine table in Fig. 42. The distance X is the only accurate dimension required, and to get this, two small parallels marked a are put in the table slot, as shown, and a straight-edge (not shown) is placed against them. Then, in this case, a 6-inch scale is put between the straight-edge and column of the machine, and the saddle screw is turned till the

scale just touches the column and straight-edge. The scale is shown dotted in under the templet at *b*. The pointer on the dial is now

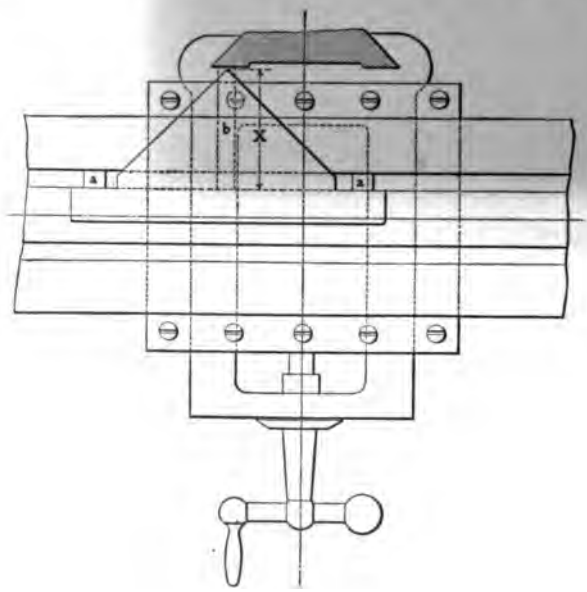


FIG. 42. — Using the Miller for Measuring.

set to zero, the straight-edge and scale are removed, and the templet is placed against the parallels, as shown. Suppose now the distance

X to be 5.986 inches. We move the table 0.14 inch closer to the column and then work the templet to fit between parallels and column.

Of course, care must be taken to see that the lost motion in nut and screw is always taken up in the right direction, and also to see if the work touches, by moving it, rather than by turning the screw till a touch is felt. The more the screw and nut are worn, unless the wear is uniform, the less reliable the results will be, but in general, if the work to be gaged does not vary more than an inch from the length of the scale or rod used, the measurement will be close enough for the allowance for press fits (0.001 inch per inch) and much other work that often strikes the general shop.

DRAW-IN CHUCK FOR THE DIVIDING HEAD

FIG. 43 shows a Brown & Sharpe dividing head holding a draw-in chuck. The arrangement consists of a collet, a bushing, a rod, and a ring. The collet a is made of mild steel to fit the head

of the spindle like an ordinary center. At the rear end is placed a bushing *b* with a turning fit in the hole of the spindle, and a shoulder on this bears against the round tail end of the spindle, as shown in the sectional view. The rod *c* has a

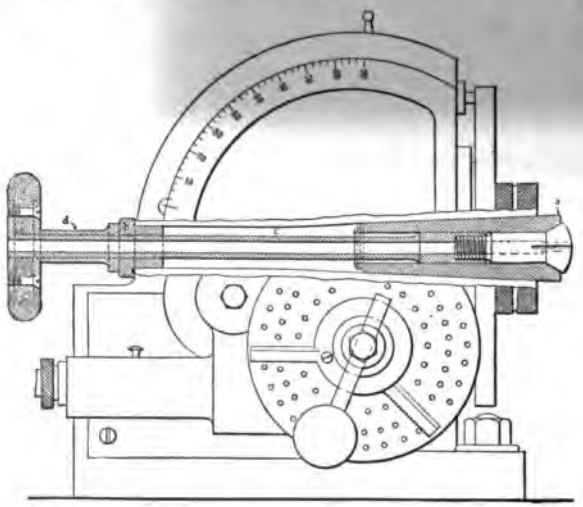


FIG. 43. — Draw-in Chuck for Dividing Head.

⅝-inch hole through its entire length, and is a turning fit in the hole of the collet *a* and the bushing *b*. The forward end is threaded to receive all sizes of bench lathe chucks. The other end is [illegible] with a round handle as on any ordinary

bench lathe, with a ring *d* driven on to the rod between the handle and bushing *b* to serve as a washer. This device is invaluable for finishing small taps, reamers, etc., and other work right from the bar.

MILLING MACHINE ATTACHMENT FOR INTERNAL SLOTS

THE milling attachment shown in Fig. 44 was designed to meet the need for an efficient device

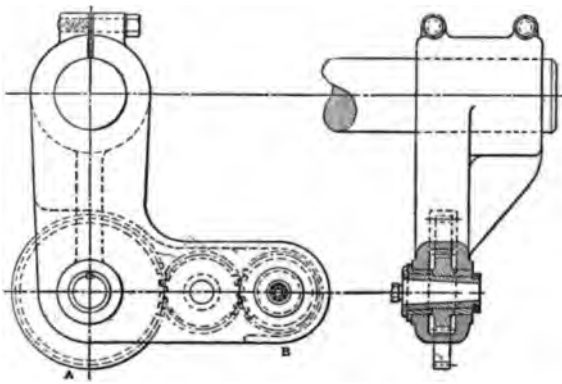


FIG. 44. — Internal Milling Fixture.

for milling a $\frac{3}{4}$ x $\frac{3}{16}$-inch slot 3 inches long, in the inside of a hollow casting $3\frac{3}{4}$ x $4\frac{1}{2}$ inches inside measurements.

hc casting is shown in Fig. 45. The attach-
ıt, Fig. 44, fits on the overhanging arm of a
ling machine, and the work spindle drives the

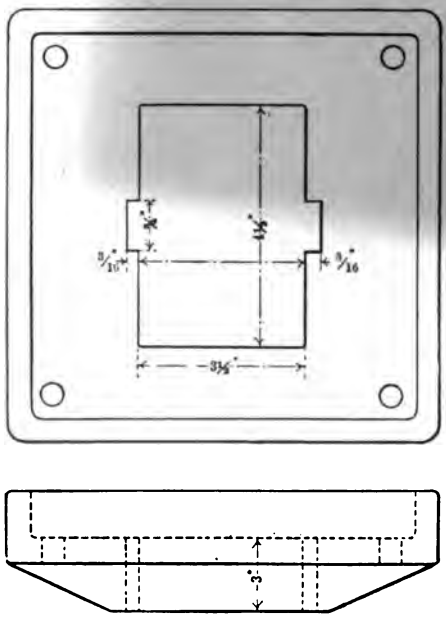


FIG. 45. — Casting in which Slot is Milled.

gear *A*, which in turn drives the gear *B*, mou
on the end mill spindle as shown. The i
mediate gear is used for the purpose of sec

the necessary length of arm carrying the cutter.

It was first attempted to cut the slot in the casting by means of a special tool in the shaper, but the length of time consumed in the operation made necessary the design given, which reduced the time of cutting to one-fifth that required by the shaper. The design with modification is of course suitable for a great variety of internal milling operation.

MILLING BRASS SEGMENTS

HAVING a number of small brass segments to finish, and not having a lathe large enough to take them, we made a frame to hold them in the milling machine, as shown in Fig. 46.

The center support was turned up and stud *A* used as a center on which to swing the frame. The bottom of the frame fitting in the T-slot in the platen was kept rigid and true. The stud *B* fastened in the frame worked between the blocks *C C*, which were bolted to the platen. The work was clamped by the set-screw as shown.

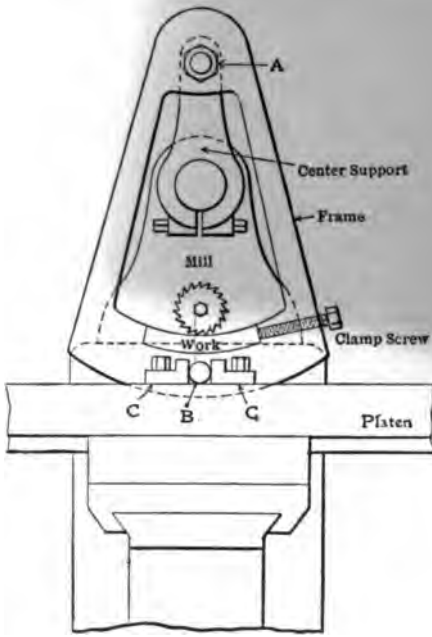


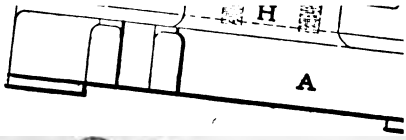
FIG. 46. — Milling Brass Segments.

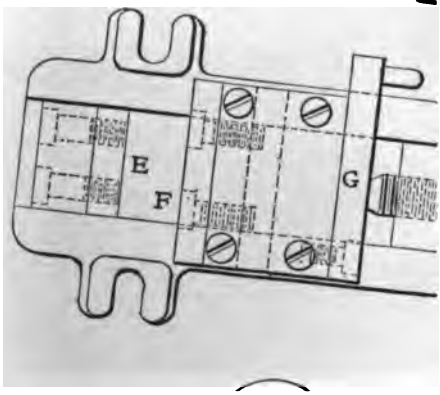
The feed being thrown in, the platen actir
on stud *B* swung the frame, and the work w
thus fed under the cutter and milled.

A HANDY MACHINE VISE

FIG. 47 shows a handy form of small machine vise, suitable for rapid work on milling machines, etc. It has proved its worth many times over.

The body *A*, of cast iron, is secured to the platen by the two slotted ears, with bolts in the usual way. Two cheeks *H* provide a support for the cover plate *B*, which is slotted to fit the tongue on cheeks and secured by four screws. These cheeks also form a guide for the slide *C*, which is made of mild steel, and slides on the facing *K* on the body. A hardened steel jaw-face *E* is fixed with two screws on to *C*, and another, *F*, in like manner on to cover plate *B*. The end of the slide is tapped for screw *D*, which is used with a "tommy" and has a hardened point which forces against latch *G* fastened on to the cover plate, thus drawing the slide and clamping the work against fixed jaw F. The latch is used to facilitate withdrawing work and save backing the screw, it being only necessary to slack the screw and swing back the latch, so that on pushing the slide the work may be withdrawn, the


H
A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space then allowing the fingers to grip the article; but for larger work the latch is not necessary. The loose jaws can be made in a variety of forms to suit different work. This vise has been used for highly accurate interchangeable work, and has given every satisfaction.

A FIXTURE FOR HOLDING TAPER SHANKS WHILE MILLING THE TANGS

In most shops a very common job to be done is turning taper shanks on arbors, drills, chucks, reamers, etc., and forming a tang on the end. The device presented in Fig. 48 is for holding the shank while milling the tang.

The knee is of machinery steel and is rigid enough to support the work and stand the cut. The hole for the bushing is in line with the spindle hole in the index head of the No. 4 Brown & Sharpe universal milling machine. One $\frac{3}{4}$-inch bolt is sufficient to secure the fixture to the table. A split bushing bored for each size shank is provided, and in use is closed by the clamp, and can be held firmly. The operation is done at one pass of the cutters.

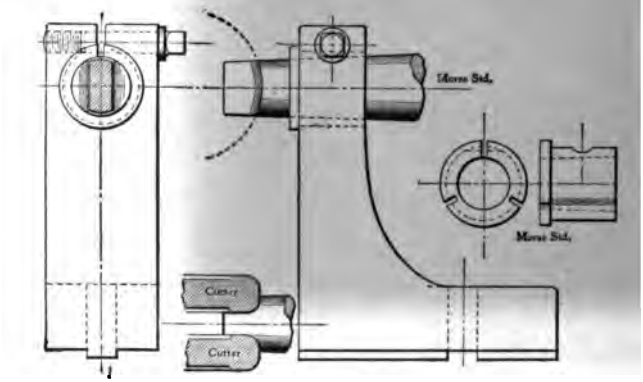

FIG. 48. — Fixture for Milling Tangs on Taper Shanks.

MILLING MACHINE VISE JAWS

THE vise jaws shown in Fig. 49 are a very useful addition to a milling outfit. Where it is required to cut a number of pieces to exactly the same lengths, they are very effective. The jaws are shown in position holding square stock, but round stock can be held just as readily. The sliding stop is easily set, and can be fastened solidly up to the under side of the ledge provided on the front jaw. The stop should hug closely *up* to this ledge when clamped, thus doing away

with the tendency to give down should the stock be pushed against it with unnecessary force. The slots across the tops of the jaws are clearance spaces for the saw to pass through, and can

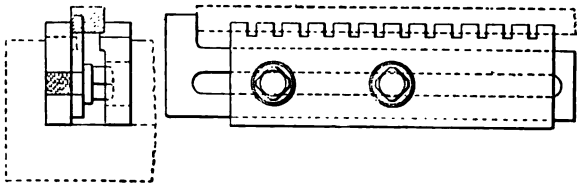

FIG. 49. — Milling Machine Vise Jaws. For Cutting Stock to Length.

be made as many or as few as desired. The right-hand stop clamp-screw can be removed entirely and the stop then slid over to the left to the end of the slot, thus greatly increasing the length that can be cut.

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